whilst that of type χ is

$$\frac{d\kappa}{dt} - \frac{\partial L}{\partial \chi} = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

We have also the additional equations

$$\Theta = \frac{\partial \mathfrak{T}}{\partial \dot{\theta}} + \Theta \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

$$\dot{\chi} = \frac{\partial \mathfrak{R}}{\partial \kappa} - \Sigma\left(\dot{\theta} \frac{\partial \Theta}{\partial \kappa} \right) \quad . \quad . \quad . \quad . \quad (11)$$

Equations (7) to (11) were first given by myself in a paper published in the Proc. Camb. Phil. Soc. for 1887; and it will be observed that they include the equations of Lagrange and Hamilton. A form of the modified Lagrangian function, which is equivalent to (7), was given by Dr. Routh a few years previously; but it is not of much practical use, owing to the fact that the elimination of the velocities $\dot{\chi}$ has not been performed.

It sometimes happens that the *co-ordinates* of the type χ do not enter into the expression for the energy of the system, in which case they are called *ignored co-ordinates*;[1] under these circumstances it follows from (9), that all the momenta κ are absolute currents. A top spinning about its point under the action of gravity is one of the most familiar examples of ignored co-ordinates, and one which illustrates several important dynamical theorems.

When there are ignored co-ordinates, the steady motion of the system, and the stability of the steady motion, can very easily be investigated. For if we suppose that all the co-ordinates θ have constant values, (8) reduces to

$$\frac{\partial \mathfrak{R}}{\partial \theta} + \frac{\partial V}{\partial \theta} = 0.$$

There are as many equations of this type as there are co-ordinates θ, and an examination of this system of equations will show whether steady motion is possible, and if so, will determine the necessary conditions which the co-ordinates θ and the constant momenta κ must satisfy.

It can also be shown that the steady motion will always be stable when $\mathfrak{R} + V$ is a minimum (see Proc. Camb. Phil. Soc. May 1892).

We have therefore the following simple rule for determining the steady motion of a dynamical system when there are ignored co-ordinates. Eliminate all the velocities corresponding to these co-ordinates from the expression for the kinetic energy of the system, so that the latter is expressed in terms of the velocities $\dot{\theta}$ and the momenta κ. Let $\mathfrak{R}$ and V be that portion of the *total* energy which does not depend upon the $\dot{\theta}$'s; then the conditions of steady motion are, that $\mathfrak{R} + V$ should be stationary, and the steady motion will be stable provided this quantity is a minimum.

The preceding theorem also enables us to deduce by a very concise method all the results connected with the steady motion of a liquid ellipsoid, which is rotating about a principal axis under the influence of its own attraction. It also enables us to examine the stability of these different cases of steady motion, for disturbances which produce an ellipsoidal displacement.

A. B. Basset.

THE PASSAGE OF GRANITE ROCK INTO FERTILE SOIL.

Having for the last three or four years paid particular attention to the natural formation of soil, I venture to believe that a concise account, or rather summing up, of the results of my researches, and of the mass of my observations—in one typical direction—may be of interest to the readers of Nature. As indicated in the heading, the making of soil from granite is the only section of a very large subject which will be briefly considered in this paper.

The agents concerned with the turning of granite (or any other rock) into a fertile soil may be shortly classified as mechanical, chemical, and vital. The first-named produce the largest results in bulk, and the principal mechanical agent with which we have to deal is frost. The second and third classes of forces are extremely important, as it is by their actions that the raw material of plant-food is prepared, though unfortunately poisons also are brought into being through their activity. These last-named classes, however, likewise materially aid the action of frost (or, in tropical countries, of varying temperatures) in the mechanical separation of rocky matter. To render my descriptions as little confusing as possible I will endeavour, without regard to classification, order, or divisions, to trace the history of a granite soil as I have observed it in many localities in Scotland, from the practically unbroken rock into the condition in which it has been made by nature fit to bear the most luxuriant crops. But first of all I must remind my readers of two or three geological facts about granite. It is a holocrystalline (*i.e.* wholly crystalline) igneous rock, composed essentially of orthoclase, quartz, and mica. In its most typical condition the last-named mineral is always of the biotite or magnesia-mica species. Besides these essentials we always find (in Scotch granites at least) plagioclase, other species of mica than the essential, apatite as an endomorph, *i.e.* locked up in the mass of other minerals, and magnetite, and almost invariably, if not always, a little pyrites, and more or less hornblende, &c.

A rough mineralogical analysis of Kemnay granite taken from the lowest working of the well-known quarry in Aberdeenshire gave the following percentages:—

Orthoclase-felspar	42·00
Quartz...	22·00
Biotite-mica	20·00
Plagioclase-felspar	9·00
Hornblende	3·25
Muscovite-mica	2·00
Magnetite (and Ilmenite)	1·00
Pyrites	0·50
Apatite	0·25
Total	100·00

The first change which comes over granite is the peroxidation of some of the iron always present in its mass. This sets in, and increases to the greatest extent, of course, where air and water can most readily enter. The surface of the rock becomes browned with the hydrated ferric oxide formed, and brown skins, of a deeper colour than the surface generally, coat the walls of the original rock joints. But in the mass of the rock, away from these primary fissures, there are areas which are more permeable than others from the surface, and through these, streaks of ferric oxide—anhydrous first, afterwards hydrated—are produced. Those lines of rust are the beginnings of a new set of joints, which have not yet been properly recognized in geological literature, and which I will here call weather joints to distinguish them from the primary joints of consolidation and rock movements. The first oxidation streaks of the coming weather fissures are invisible to the eye, but can be determined under the microscope. They gradually increase in width above as they extend their lines beneath, and they afford passages through which water can more readily percolate than in the surrounding fresher areas, and as a consequence planes along which frost can more powerfully act. By the constant multiplying of the weather joints, which are first marked out by oxidation as already indicated, and afterwards made definite and widened from the most exposed rock surface inwards by frost, one of the first steps in soil formation is accomplished. As those fissures are increased the uppermost portion of the rock is separated by them into distinct pieces, which latter are again in their turn broken up by the formation of weather joints in the same way as the original. The great bulk of a soil has been produced in this way.

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[1] I must confess that I do not like the phrase *speed co-ordinates*, introduced by Prof. J. J. Thomson, for it conveys absolutely no meaning to my mind. I have no sympathy with the attempts, which have occasionally been made, to introduce short words of Teutonic origin into scientific nomenclature, as the words in question appear to me to be singularly deficient in point.

While the oxidation of the iron, as I have observed, is very likely the first change to set in in every case, it is never left for any lengthened period to promote, by itself alone, the decomposition of the rock. Very soon the work of carbonation is seen to be progressing alongside of it, though at a considerably slower rate. The carbonic acid gas of moist air, dissolved in the penetrating water, attacks the felspars, the biotite, and the hornblende. The way in which it brings about the decomposition of these minerals is interesting. Certain molecules succumb much more easily to the action of the carbonic acid than others, and the result is that scattered points of weakness from the thorough decomposition of these are brought into being in different parts of the mineral, and those decomposed portions warp round about the other and fresher molecules, as shown in the annexed diagram, which has been constructed from what I have observed in decomposed felspars.

The clay of decomposed felspar has great plastic and warping power. I have observed only 15 per cent. of pure clay in a mass hold the 85 per cent. of other and different constituents together in a plastic union as if the whole had been pure clay. There are two or three other hitherto unknown facts connected with the natural decay of felspars which I have ascertained from my researches. I have noted two processes of decomposition—that which occurs when the carbonic acid is in excess or can obtain free access to the mineral, and that which takes place when either of the opposite conditions prevails. In the first case the felspar—supposing it to be *orthoclase*—has the molecules of its body which are affected completely broken up into clay, solid secondary or colloid silica, and carbonate of potash. In the second case, where for some reason a sufficient supply of carbonic acid cannot get within "chemical" distance of the felspar molecules, clay is produced as before—only more slowly—but the potash of the molecule is carried off in two sections, part as a carbonate, and part as a soluble silicate.[1] From the *plagioclase*-felspar the same conditions produce similar results, except that the soluble silica which would be produced here is of course in combination with sodium. I have found the soluble silica of soils *always* in the form either of silicate of potassium or sodium, and very frequently both of these occur mixed together.

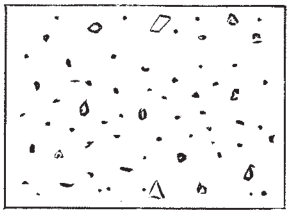

Diagram of kaolinized felspar × 260. The whole ground-mass is kaolin or pure clay; the bodies scattered through this are parts of the original felspar not yet decomposed.

Biotite, by the continued action of carbonic acid, oxygen, and water, loses magnesia (taken out as carbonate) and iron (removed either as oxide or carbonate) and becomes eventually the white or yellow muscovite variety which undergoes no further chemical change. In biotite, however, the chemical change usually takes place much more uniformly through the mineral body than ever happens in the case of the felspars.

Hornblende by carbonation, oxidation, and hydration yields lime as carbonate until the whole of that base is taken out, a trace of magnesia as carbonate (the bulk of this base is almost invariably left in the insoluble residue), the chief portion perhaps of its iron as oxide and carbonate, manganese as hydrated oxide, and any trace of sodium and potassium which it may contain as carbonates, or partially when conditions are less favourable as soluble silicates. The residue left after the hornblende has lost the above can generally be determined as some variety of chlorite (hydrated silicate of magnesia, iron, and alumina), which in the course of time by further loss of iron becomes an impure serpentine, and this later on a steatite or magnesia-clay, to which the greasy feel of soils is due.

The *pyrites* of the granite rock is slow to change, but it also is eventually acted on, by water and oxygen particularly, the latter combining with its substance here and there to form a sulphate, which has a great mission in the physiology of the soil.

I have said that the *apatite* occurs as an endomorph. It is set free to dissolve slowly without change in ordinary carbonated water when the minerals which hold its microscopic needles in their substance are broken up, mechanically or chemically. The *magnetite* and *ilmenite* grains of the granite rock are only altered with provoking slowness. Their function, however, in the work of the soil is, as far as I can see yet, of no importance. Traces at least of another mineral occur very frequently in granites. This is tourmaline, the history of which in soils I have been investigating for the last half-a-dozen years with some success.

The chemical changes which I have been mentioning begin first on the exposed surfaces of the rock and along the faces of the primary joints. Then oxidation occurs in streaks and bands through the rock mass, and around those areas carbonation is most active. In fact oxidation opens up the rock for further change, chemical as well as mechanical.

Frost is the principal agent of disintegration or mechanical breaking up in this country, but a relatively minute portion of the work is accomplished by heat and cold, the friction of percolating water, changes in the degree of humidity of the atmosphere, the pressure exerted by roots, and so on.

No sooner does a fraction of the surface percentage of the exposed rock portion undergo chemical change than a new element in the making of soil comes into play—that, namely, of organic matter, first living, and then dead and living. We will deal first with the living matter. On the partially decomposed surface of rock, fungal and algal spores (the latter of a lowly type) settle and live and grow in symbiotic union as lichens. There are many different kinds of rock-lichens, but the vegetative physiology of all is identical. The surface of the growth which lies next the stone is engaged in parts, during moist weather at least, in the imbibition of water, with the exceedingly meagre amounts of mineral matters dissolved in it from the surface of the rock. Those absorbing areas of the under surface appear to be also superficial breathing organs, for they certainly excrete carbonic acid gas, which of course will join with the atmospheric carbonic acid in helping the work of decomposition of mineral bodies. And it appears to me—though here I am not certain—that these absorbing areas are less generally found over the quartz of the granite, which is not capable of chemical change, than over the decomposable minerals. The lower absorbing areas of the lichens are in their functional relations common to internal fungal and algal members, and the upper surface of the colony is also a common absorbing (and transpiring) tissue, though here it is only the atmosphere gases which are taken in to the interior. There is not the slightest doubt but that the fungal members utilize the nitrogen of the air; there is none in the rock for them to receive; and that the algal members absorb carbonic acid gas from the air taken in, and combine it with the elements of water to make carbonaceous food, for that again is not presented to them from the rock; the lichen growth cannot any more than is the case with higher plants utilize the carbon of the mineral carbonates in the manufacture of carbohydrate or hydrocarbon food.

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[1] See also in this connection my article on "The Action of Lime on Clay Soils," NATURE, Jan. 29, 1890.

In reproduction, separate spores of algæ and fungi are produced from the lichen, and some of these may germinate above the parent community and unite to form a fresh colony upon the old, or a new colony may be produced from foreign spores. In any case we find generation after generation of lichens forming on the same favourable spot; but succeeding generations are partially parasitic and saprophytic in nature, as is shown by the manner in which their lower absorbing surfaces or prolongations act on the lichen growths beneath them. By and by, when perhaps a score of lichen colonies have formed one above the other—the newer slowly extinguishing the life of the older—a vegetable considerably higher in the scale of being comes forward and caps the last lichen. This is some variety of moss. Spores of mosses, carried to the stone surface, germinate there in moisture, and if upon lichens, the moss plantlet develops into the adult. Its rhizoids pierce their way through the substance of the lichens, and many get down to the decomposing stone surface, while some never leave the lichen bodies. The action of the moss rhizoids on living and dead lichens, also, I think, shows that that plant can be a parasite and a saprophyte as well as a normal vegetable feeder; and in this respect, except in its not utilizing the nitrogen of the air, resembles the later lichen growths.

In this way, by the succession of lichens and mosses (and afterwards higher plants), the essential organic element of soils becomes early incorporated with the mechanically and chemically disorganizing rock.

The dead organic matter changes in different ways: first, very slowly and very indifferently, by the action of air and water; and second, rapidly, by the spreading through its mass, where air has free access, of bacteria and other lowly fungi which are saprophytic, but can also assimilate nitrogen from the atmosphere, as is shown by their increasing, and not simply maintaining the original amounts of nitrogen left by their predecessors. By the first method of change the organic matter becomes the tougher former of humus, and humic and other related acids arise from it; by the second the mild, dry, or friable humus is produced and little or no humic acid. A very careful investigation shows that those bacteria which have the power of removing from the dead organic matter the elements of their nutrition give out by the decay (which occurs rapidly) of their bodies when they die the nitrogen and other elements in an active state. The nitrogen of the dead bacteria forms readily nitrate of lime or potash by contact with these bases.

Now to give a short summary here. Oxidation of iron is the first change perceivable in granite; then creation and multiplication of weather joints, and carbonation follows; next humus is formed by lichens, and then higher plants; following this, fungoid germs, capable of assimilating aerial nitrogen, become abundant; finally all the three processes, mechanical, chemical, and organic, go merrily on together and contribute all in their proper shares to the formation of an ever-deepening soil, capable of supporting the luxuriant life of the highest plants. The humic acid which is formed by the inorganic decay of humus has a certain decomposing action, but it gradually changes to carbonic acid, with the action of which, in this connection, we have already dealt. Well, to apportion the shares of the work done further. By disintegration, or mechanical action, the great rough mass of the soil is produced. By oxidation and carbonation, soluble minerals capable of entering the plant are prepared, and insoluble matters like secondary silica, pure clay, and steatite, are brought into being. By the action of living matter, rock decomposition is hastened, and nitrogenous substance is brought into the soil. By the presence and action of dead organic matter, rock decomposition is also forwarded, and a field for aerial nitrogen-assimilating germs is prepared. The table below gives a list of the materials found in the youngest granite soil on which nothing higher than rock-mosses are growing.

Granite minerals in fairly fresh condition	About 80 per cent.
Clay and insoluble secondary silica ...	About 3 per cent.
Soluble silica	Not determinable.
Carbonates of potash, soda, lime, magnesia, iron, and phosphate of lime	About 2 per cent.
Sulphates of above, except iron	Not determinable.
Sulphate of iron	Merest trace.
Peroxides of iron and manganese ...	About 3 per cent.
Humus	12 per cent.
Total	100 per cent.

Later on, as the soil deepens, we find some curious changes proceeding, which I will briefly indicate. Sulphates are now produced in considerable quantities. Wherever iron-containing minerals are brought into contact with organic matter, sulphate of iron tends to form as well as carbonate (humate ?), and possibly other compounds; and the pyrites which was slow to change at the beginning now produces sulphate of iron with greater rapidity. The dissolved sulphate of iron coming into contact with the carbonates of the alkalies and alkaline earths liberated from the felspars, hornblende, &c., as already explained, causes a double decomposition. The ferrous sulphate becomes a carbonate, and the carbonates of lime, potash, soda, &c., become sulphates. The iron carbonate, where exposed to air, readily oxidizes to ferric oxide, the chief colouring ingredient of the soil.

Now, in the finished soil, which, it must be remembered, is when produced from granite a loam, we have the following approximate composition, as fairly typical of a good granite soil such as may be found in the valley of the Don in Aberdeenshire:—

			Per cent.
Insolubles	Pure clay and steatite	about	10
	Quartz and secondary silica ...	,,	20
	Muscovite	,,	4
Substances capable of transformation	Orthoclase...	,,	30
	Plagioclase	,,	4
	Biotite	,,	9
	Magnetite?	,,	0·5
	Hornblende	,,	2
	Hematite and limonite (ferric oxides) and manganic oxide	,,	9
	Pyrites	,,	0·5
	Humus and animal organic matter, fungi, &c....	,,	5
Injurious solubles	Humic acid	,,	0·5
	Soluble silicate	,,	0·3
	Ferrous sulphate[1]	,,	0·5
Non-injurious solubles	Phosphates of lime, magnesia, potash, soda, &c.	,,	0·3
	Sulphates of lime, potash, soda, magnesia, &c.	,,	0·8
	Nitrates of lime, potash, soda, magnesia, &c.	,,	0·3
	Carbonates of lime, potash, soda, magnesia, &c.	,,	0·1
	Chlorides of above	,,	Trace.
Water and air (mechanically held) in dry summer perhaps about		,,	3·2
	Total		100·0

[1] More than 0·1 per cent. is injurious.

In conclusion I have to point out, as shown by my investigations commenced four years ago, that farmyard manure laid on to the land is only rendered properly available to the crops by the action of bacteria as indicated above in connection with the natural humus. The inorganic forces have little action upon it, except in producing humic acid and other injurious matters.

The most of the soluble mineral substances in a mature soil, it may also be mentioned, are in the form of sulphate. They originate from the primary minerals as carbonate, but are soon altered, mainly by the ferrous sulphate. The sulphate unfortunately is not the most suitable form in which minerals can be presented to plants for absorption, for the simple reason that, being so stable in chemical union, it causes the loss of too much of the plant's energy in the interior of its body before it can be decomposed. It must be remembered that green plants decompose the compounds which enter their system before they utilize their elements or simpler forms in the elaboration of food. ALEXANDER JOHNSTONE.

Edinburgh, August 5.

THE IMPERIAL INSTITUTE AT ST. PETERSBURG.[1]

IN November, 1885, some months after the publication of Pasteur's discovery for the treatment of hydrophobia, an officer of the Russian Guards was bitten by a rabid dog. This officer having been sent to Paris to undergo the treatment, his Highness Prince Alexander Petrowitch d'Oldenburg established, at his own expense, a provincial laboratory at St. Petersburg, where Pasteur's treatment could be duly carried out. This establishment, however, soon proved to be too small for scientific investigations to be properly carried out therein, and it was decided to build a large laboratory in which researches might be made under the best possible conditions; accordingly the same enlightened nobleman bought a piece of ground of 37,464 square metres in extent, on which the present Institute is built.

The buildings comprise physiological, pathological, chemical, bacteriological, and epizootological sections, with their laboratories, under the direction of such men as Neucki, Winogradsky, and others. There is also a department where Pasteur's treatment is carried out, together with a small hospital for infectious cases. Each section is complete in itself, and all the arrangements are on the newest principles and on a very large scale. The expenses are defrayed partly by the Prince of Oldenburg and partly by public subscription, and the whole Institute compares favourably with any Institute in France or Germany.

The directors of the Institute publish every two or three months a volume embodying the scientific results obtained in the laboratories, and the first two numbers have now been published. As might be expected after what has just been said, their contents are of wide and varied interest. Neucki publishes some chemical researches on the microbe producing inflammation of the mammary glands of milch cows and goats, and his paper will specially interest those who in this country have followed the remarkable researches of Dr. E. Klein. Winogradsky gives an account of the various nitrifying organisms discovered by him in the soil of different countries. This author quotes the researches of Prof. and Mrs. Frankland, and of Prof. Warington, and though to some extent contradictory, Winogradsky's researches agree with those of the English observers in all essential particulars. This paper is certainly the most important which has as yet appeared on this vexed question. The results obtained by Pasteur's treatment in St. Petersburg form the subject of a paper by Kraïouchkine, and it may be mentioned that the treatment appears to have been as successful at St. Petersburg as in Paris.

The other papers refer to the chemical and physiological effects of tuberculin (Bujwid, Helman), to the transformation of nutritive media by the bacillus of diphtheria, and to the chemical composition of this micro-organism (Dzierzgowski and Rekowski), while Blachstein endeavours to draw a distinction between the bacillus coli communis and the bacillus typhi abdominalis, based on the chemical decompositions produced by these organisms in the media in which they grow. Lastly, Mizerski and L. Neucki give a critical *résumé* of the methods used to estimate the quantity of hydrochloric acid contained in gastric juice.

The researches which form the subjects of these papers are varied enough, and whilst congratulating their authors we may express the hope that the Institute will have a long and prosperous career. Our good wishes must be tinged with regret for ourselves—regret that there should not be a similar Institute in England, and regret also that there should be in this country a class of people who will oppose the establishment of such an Institute until a Bishop or Royal Duke has died of rabies.

M. ARMAND RUFFER.

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[1] "Archives de Sciences Biologiques publiées par l'Institut Impérial de Médecine Expérimentale à St. Pétersbourg," Vol. 1, No. 1 et 2.

NOTES.

LAST week much anxiety was felt as to the health of Sir Richard Owen. On Monday his condition was better, and the improvement, was maintained on Tuesday.

THE herbarium of the British Museum has acquired, by presentation from the widow, the very valuable collection of Muscineæ, made by the late Mr. George Davies, of Brighton. It comprises upwards of 20,000 specimens of mosses, hepaticæ, and lichens, partly gathered by Mr. Davies in Great Britain and on the Continent, partly communicated to him from New Zealand, Samoa, India, the West Indies, and America.

PROF. HIERONYMUS has been appointed curator of the Royal Botanical Museum at Berlin.

THE Exhibition of the Photographic Society of Great Britain was opened on Monday at the Gallery of the Royal Society of Painters in Watercolours. It will remain open till November 10.

WE regret to have to record the death of Mr. George Croom Robertson. He was fifty years of age, and only lately, in consequence of ill-health, resigned the professorship of Mind and Logic at University College, London, to which he was appointed in 1866. Prof. Robertson was well known as a brilliant teacher of the subjects to the study of which he devoted his life, and as the editor of *Mind*. He was associated with Prof. Bain in the editing of Grote's "Aristotle," and was the author of the volume on Hobbes in Blackwood's series of "Philosophical Classics." He also contributed to the latest edition of the "Encyclopædia Britannica."

DR. GEORGE DIXON LONGSTAFF died at Wandsworth on Friday last in his ninety-fourth year. When a young man he was assistant to Dr. Hope, Professor of Chemistry at the University of Edinburgh, and he is believed to have been the first teacher of practical chemistry to medical students in this country. He was one of the founders and a vice-president of the Chemical Society of London.

Students of folklore will be sorry to hear of the death of Reinhold Köhler, librarian at Weimar, where he was born in 1830. He died on August 15. Dr. Köhler was a man of great learning, well known as an authority on the subject in which he was chiefly interested.